MEASUREMENT OF WHEAT DENSITY

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ABSTRACT

A method used for on line determining the change of wheat density with a automatic watering machine in a large flour mill has been studied. The results show that the higher distinguishing ability is obtained when using ^{241}Am as a γ-ray source for measuring the wheat density than using ^{137}Cs.

Keywords γ-ray, ^{241}Am, ^{137}Cs, Density of wheat

1 INTRODUCTION

Appropriate amount of water should be added to the dry wheat before its milling. Its moisture content is measured with microwave techniques in the automatic watering machine of wheat (AWMW). By measuring the change of γ-ray intensity before and after watering the change of wheat density can be determined. The percentage content of the moisture in the wheat can be worked out after treating the signals from microwave and γ-rays with a microcomputer. And then the computer will give an order for automatically adding some expected volume of water to the wheat under milling.

Nowadays, ^{137}Cs is used as a γ-ray source in AWMW for measuring the density of wheat, the γ-ray detector is a high gas pressure ionization chamber. However, the more powerful radiation source (in general, $9\times10^8\sim1\times10^9$Bq) should be used in order to get a certain measuring precision since the energy of ^{137}Cs γ-rays is relatively powerful (0.662 MeV), this causes inconvenience in its preparation and radiation protection. To find a better method for measuring the density of wheat, this research work has been made.

2 EXPERIMENTAL

The standard NIM insertions are adopted in the experimental instrument, between the detector and the radiation source a wheat container whose width can be changed from 5.5 cm to 17.5 cm, is fitted, so that the wheat passage-way with different widths can be imitated in the experiment (see Fig.1).

The specific gravity instrument type HGT–100 is used to measure that of wheat. The scintillation detectors which are suitable to measure the γ-ray energy of ^{241}Am and ^{137}Cs are adopted, respectively. When the original measurement method is imitated, the high gas pressure ionization chamber (ϕ150 mm$\times$1165 mm) used to measure the wheat density at the type FZSZ–9500 AWMW made in China is used to detect the γ-rays of ^{137}Cs radiation source. The output current from the ionization chamber is measured by the active capacitor electrometer type FJ–365.

Manuscript received date: 1994-09-02

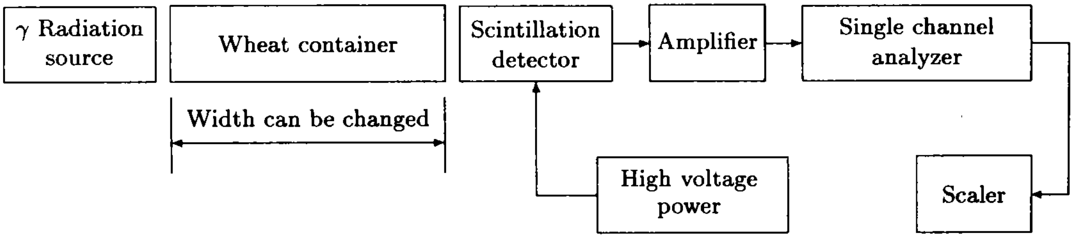

Fig.1 Block diagram of the experiment installation for the wheat density measuring

The γ-ray signals from ^{241}Am or ^{137}Cs are determined when the experiment is carried out changing the distances between the detector and the radiation source.

3 RESULTS AND DISCUSSION

3.1 Measurement of ^{241}Am γ-rays under the conditions of different thickness and unit weight of the wheat

The scintillation detectors are adopted as the γ-rays detectors. The experimental data are shown in Tables 1 and 2. Comparing the data from Tables 1 and 2, one can find that there is no remarkable difference between them, that means an easier made plane ^{241}Am source is a sufficient one for measurement in this case.

Table 1
The imitation experiment data measured with ϕ15 mm plane ^{241}Am source

d	A /%	B /%		
/cm	762.3g/l	682.0g/l	666.1g/l	649.3g/l*
5.5	43.0	1.9	7.2	12.1
8.4	60.1	4.0	9.9	15.1
11.5	71.0	10.0	14.1	22.7
14.4	78.5	14.5	16.5	27.6
17.5	85.2	21.1	28.0	31.1

Table 2
The imitation experiment data measured with a ^{241}Am source (10mm×200mm)

d	A /%	B /%		
/cm	762.3g/l	682.0g/l	666.1g/l	649.3g/l
5.5	46.2	4.6	11.5	13.3
8.4	60.6	6.7	14.1	15.3
11.5	71.2	9.3	19.5	18.0
14.4	80.2	14.4	22.8	24.5
17.5	86.3	16.5	33.1	34.9

* Unit weight of wheat, *d*—Distance from source to detector

A: The relative percentage of comparing the γ counting rate weakened by dry wheat to no wheat weakened one (similarly hereinafter)

B: The relative percentage of comparing the γ counting rate weakened by wet wheat to dry wheat weakened one. (similarly hereinafter)

3.2 Measurement of ^{137}Cs γ-rays with different distances (d)

The activities of ^{137}Cs sources are 5.3×10^5Bq and 9.6×10^8Bq respectively, and the detectors are a scintillation detector or a high gas pressure ionization chamber. The experimental data are shown in Tables 3 and 4.

Table 3
Experiment data measured with 5.3×10^5 Bq ^{137}Cs source and scintillation detector

d	A /%	B /%		
/cm	762.3g/l	682.0g/l	666.1g/l	649.3g/l
5.5	4.9	0.1	0.4	1.2
8.4	7.0	0.4	1.8	3.6
11.5	16.0	2.5	2.8	6.4
14.4	13.0	3.6	5.3	7.6
17.5	19.2	4.9	6.5	8.2

Table 4
Experiment data measured with 9.6×10^8 Bq ^{137}Cs source and high gas pressure ionization chamber

d	C /%	D /%
/cm	762.3g/l	649.3g/l
8.4	6.7	4.0
14.4	11.8	7.1

C,D are the relative percentages of comparing the current output with dry wheat to that without wheat and with wet wheat to that with dry wheat,respectively

Comparing the results from Table 1 and Table 3, it is obvious that ^{241}Am source is much more efficient for measurement, the B values of Table 1 are 3.1–19 times more than those of Table 3.

From the Tables 3 and 4 it can be seen that B and C or D are almost the same when comparing the wet and dry wheat in the container at the condition of the same to the unite weight of wheat and the distance between the radiation source and detector.

3.3 The static state experiment on the type FZSZ–9500 WAWM

The linked experiment has been carried out with type FZSZ–9500 WAWM using scintillation detector and plate ^{241}Am source in order to prove the data mentioned above. The state of the wheat in the wheat passage-way is a static state when the experiment is carried out. The width of the passage-way is 75mm. The experiment data are shown in Table 5.

Table 5
Experiment data obtained from FZSZ–9500 WAWM using scintillation detector and ^{241}Am source

Wheat density	752 g/l (dry)	680 g/l	684 g/l	651 g/l
Instantaneous measuring value (cps)*	5450	5816.4	5817.6	7000.2
Value 5 min after inletting (cps)	4925.0	5695.6	5773.0	5972.4

* The measuring value of γ-rays at the moment of wheat inletting

From Table 5 it can be seen that the increasing value of the γ-ray counting rate at 651 g/l and 752 g/l in the instantaneous measuring is 28.4% [(7000.2–5450)/5450], after 5 min is 21.3 % [(5972.4-4925)/4925]. However, this increase, in use of ^{137}Cs source and ionization chamber, only reaches 3.9%. The different measuring values between the "instantaneous" and "5 minutes later" in table above are caused by the subsidence of the wheat itself.

3.4 The absorbing of γ-rays by iron and plexiglass

Attention must be paid to the absorbing of γ-rays by the wheat passage-way wall which is made of iron. It is considered that the generator and receiver of microwave signals are mounted on the wheat passage-way (iron made) of FZSZ–9500 WAWM, microwave measuring has been solved by making a hole on the iron passage-way with a plexiglass window.

Table 6

Experiment data of γ-rays of ^{241}Am source absorbed by iron

Thickness of iron plate /cm	0	2	4	6
γ-ray counting rate /cps	38533.5	4057.8	1031.3	518.4
γ-rays absorbed /%	0	89.5	97.3	98.7

Table 7

Experiment data of γ-rays of ^{241}Am source absorbed by plexiglass

Thickness of plexiglass /cm	0	5	10	15
γ-ray counting rate /cps	38533.5	31538.9	27021.9	23747.9
γ-rays absorbed /%	0	18.2	29.9	38.4

So the measurements of absorbed ^{241}Am γ-rays by iron and plexiglass have been made. The results are presented in Tables 6 and 7.

Obviously, from the data of Table 6 and 7 the thickness of 5cm iron or plexiglass is the best choice in practice.

4 CONCLUSION

From the experimental data shown in Tables 1–4, it can be seen that the farther the distance between the radiation source and the detector is, the more increasing persentage of the γ counting rate in the experiment region is when comparing the wet and dry wheat which located between the radiation source and the detector.

From the γ-ray absobing experiment by iron and plexiglass, it can be sure that the γ-rays absorbed by the wall of the wheat passage-way can be reduced effectively if ^{241}Am source is used as a γ-ray source of the WAWM, and the plexiglass as the wall of the wheat passage-way between the γ-ray detector and ^{241}Am source. The radioactivity of ^{241}Am radiation source used in the experiment could be decreased greatly at the condition of accuracy demanded.

From the experiment results above it can be sure that using ^{241}Am is better than ^{137}Cs for measuring the wheat density in the WAWM. The increasing percentage of γ-ray counting rate is 3.1–19.0 times in use of ^{241}Am source than that of ^{137}Cs, when comparing wet wheat and dry wheat in the wheat passage-way. So the higher distinctive ability will be got when the ^{241}Am source is used for measuring the density change after the wheat watering.